

Cell Phones, Microwave Ovens, and Wi-Fi – Can They Cause Cancer?

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05 February 2018 (r06)

Preamble

This document is an extension of *Cell Phones and Cancer* first prepared in 2010. This current document will explain why it is extremely unlikely that cell phone, Wi-Fi, and microwave oven radiation will cause cancer. Cancer involves the unregulated growth of cells and is believed to be initiated by broken carbon-carbon bonds in DNA. The energy in cell phone radiation is about 2.8 million times weaker than the energy (strength) of a carbon-carbon or other atom-atom bond. The energy of the radiation from microwave ovens and Wi-Fi systems is approximately 300,000 times weaker than that of chemical bonds. The probability that these radiations can disrupt DNA and thus be a precursor to cancer is vanishingly small.

Those who assert that EM (electromagnetic) radiation from cell phones, microwave ovens, or Wi-Fi systems¹ is dangerous to the public must provide scientific and medical evidence that there is a causal link between symptoms and the energy of these devices. This evidence must also include a mechanism, or at least a theory, describing how the cancer is produced. To date, this has not been done. Many investigations to date have failed to find a credible link.

It is my personal opinion that if cell phone, microwave oven, and Wi-Fi radiation caused cancer and other definable ills, then we should have observed a significant worldwide increase in these ills since the 1980's, roughly the onset of a significant increase in the worldwide use of electromagnetic media. Since the late 19th century, we have been immersed in electromagnetic radiation from radio broadcasting and electrical power transmission. Before that time, we have survived over eons of cosmic rays and naturally occurring radioactivity. If such radiation is so bad for us, why are we still living?

Introduction

J. E. Moulder et al. (Radiation Research **151**, 513-531 (1999) in a comprehensive review, "Cell Phones and Cancer: What is the Evidence for a Connection?" makes the following statement in the abstract: "**Overall, the existing evidence for a causal relationship between RF radiation from cell phones and cancer is found to be weak to nonexistent.**" The final paragraph of their Conclusions states:

The controversy about cell phones and cancer is likely to continue either until clear-cut evidence of a hazard is established or until the public (including politicians, businessmen, lawyers, and journalists) concludes that there is little likelihood of a real and significant hazard. Perhaps the greatest contribution that scientists can make to this debate is to help educate the public (and other scientists) about the uncertain nature of risk assessment, and about the breadth of disciplines and rigor of analysis that must be brought to bear if high-quality risk assessment is to be accomplished.

I will attempt to provide the physical basis for the assertion that non-ionizing cell phone radiation cannot break chemical bonds because the energy of that radiation is far below the energy required for breaking chemical bonds. Therefore, cell phone radiation is not a cause of cancer if cancer results from the breaking of chemical bonds (such as carbon-carbon) which, in turn, disrupts the normal functioning of DNA, mitochondria, or other chemical processes within the body ultimately leading to unregulated (and hence cancerous) cell growth. It will be shown that the energy required to break a chemical bond is many orders of magnitude greater than that possessed by the microwaves used by cell phones, Wi-Fi, and microwave ovens.

What is Necessary to Produce a Cancer?

A minimum requirement is that enough energy is introduced into the receptor site to break a chemical bond in DNA or other molecules so that the normal repair and growth processes are interrupted and a pathway to possible unregulated cell growth (cancer) is opened. It is well known that nuclear radiation, x-radiation, and solar radiation (UV-A and UV-B) can cause cancer. This is consistent with the cause of cancer as set forth in an excerpt of an article from the Mayo Clinic (See Appendix A). Their statement under Causes is:

“Cancer is caused by changes (mutations) to the DNA within cells. The DNA inside a cell contains a set of instructions telling the cell how to grow and divide. Errors in the instructions may allow a cell to become cancerous.”

A mutation² is an alteration of DNA at the atomic level involving the disruption of carbon-carbon (C-C, C=C, C≡C) bonds. It will be shown that energetic ionizing radiation (ultra-violet light to cosmic rays) possess sufficient energy to break a carbon-carbon chemical bond (or other chemical bonds such as carbon-sulfur, etc. whose energies are similar) in molecules such as DNA and thus can open a possible pathway to cancer through the resulting mutation.

Will Breaking a Bond in DNA Necessarily Cause Cancer?

Most emphatically NO. Breaking a chemical bond in DNA is necessary but not sufficient to cause cancer for several reasons, some of which are:

- Only a small number of key bonds among the estimated 200 billion atoms in a DNA strand, when broken, could lead to cancer,
- The tremendous redundancy built into DNA,
- The repair process that takes place as DNA strands are replicated weeds out many potential cancer-causing defects,
- The body’s natural defenses, as evidenced by the sometimes-observed spontaneous remission of a cancer.

Apparently, cancer results from a series of probabilistic events going “wrong”.

Cancer can also happen through a chemical insult when a carcinogenic agent interacts chemically with DNA. In this situation, bonds are not broken by high-energy photons but are reconfigured through chemical reactions. Again, not all such chemical interactions will cause cancer because of the natural repair processes.

The Electromagnetic Spectrum

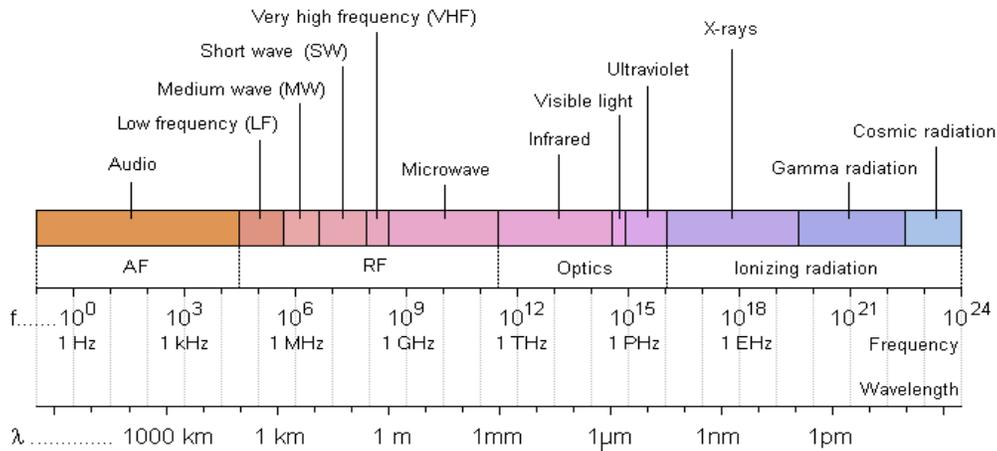


Figure 1 – The Electromagnetic Spectrum³

The first thing to note in Figure 1 is the position of X-ray, Gamma, and Cosmic waves (to the right) relative to visible light, infrared, radio, and audio waves (towards the left). The left to right scale is increasing energy (frequency), low energy at the left increases to high energy at the right. Cell phone and Wi-Fi frequencies (1 to 5 GHz)⁴ lie in the lower energy microwave region. The microwave region is far removed from the higher energy ultraviolet rays and radiation to the right in Figure 1 which is known to cause cancer. The wavelength λ is shown at the bottom of Figure 1. Here m stands for meter in the Metric System: 1 m = 39.37 inches = 3.28 feet. Do not confuse this m (meter) with the prefix m for milli in Table 1.

Table 1 show the SI (Systeme Internationale) prefixes used in the Frequency and Wavelength scales in Figure 1. Not all of the prefixes in Table 1 are used in this document but are included for completeness.

Table 1: SI prefixes

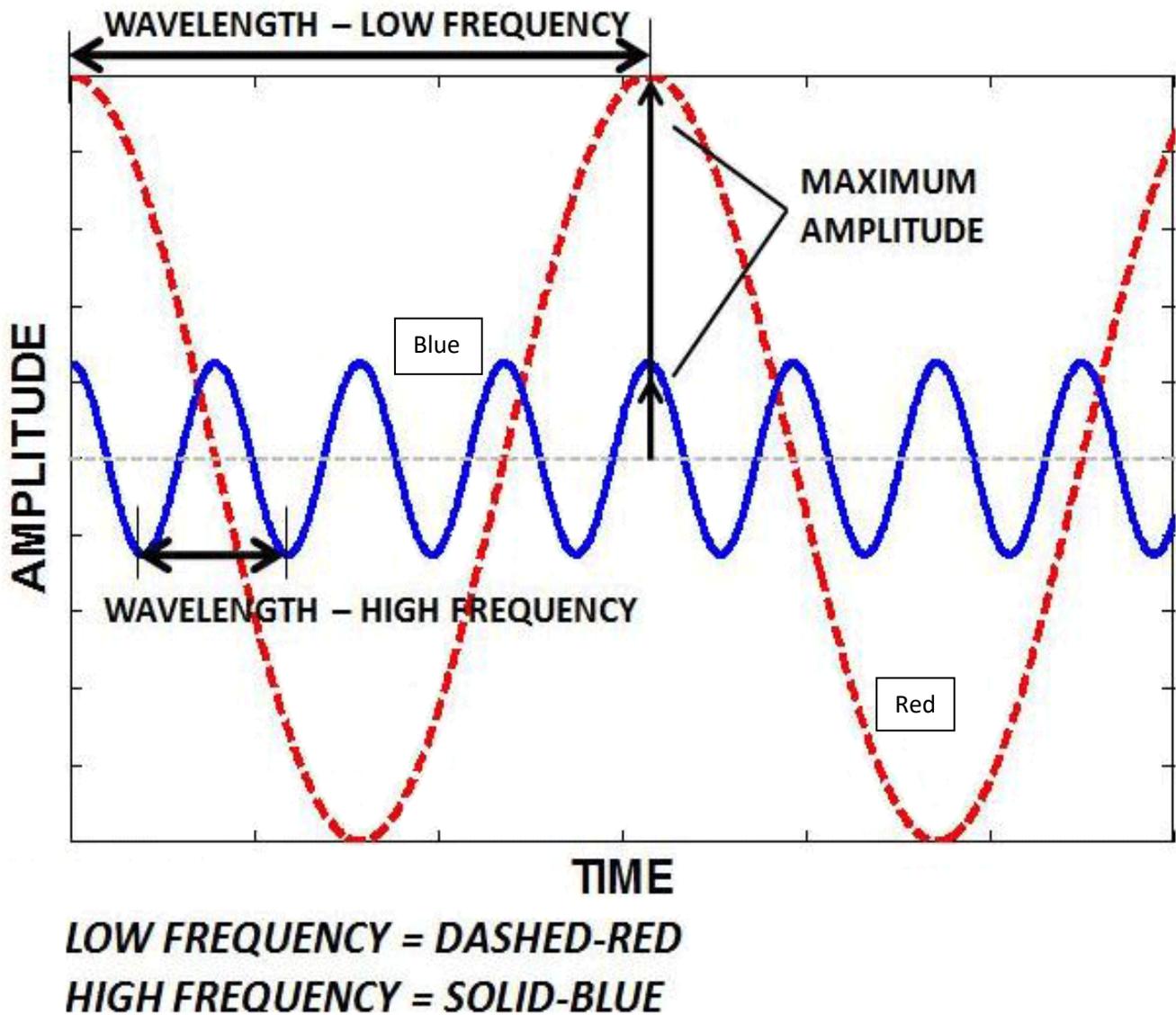
Factor	Prefix	Symbol	Factor	Prefix	Symbol;
10 ¹⁸	exa	E	10 ⁰	No prefix	
10 ¹⁵	peta	P	10 ⁻¹	deci	d
10 ¹²	tera	T	10 ⁻²	centi	c
10 ⁹	giga	G	10 ⁻³	milli	m
10 ⁶	mega	M	10 ⁻⁶	micro	μ
10 ³	kilo	k	10 ⁻⁹	nano	n
10 ²	hecto	h	10 ⁻¹²	pico	p
10 ¹	deka	da	10 ⁻¹⁵	femto	f
			10 ⁻¹⁸	atto	a

Electromagnetic radiation is described as a wave moving through space. The wavelength is the distance between the adjoining crests of the wave, Figure 2. This distance is represented by the Greek letter λ, lambda. As shown in Figure 1, λ varies from a very short distance, 1 pm to 1,000 km. A meter equals 39.37 inches or 3.28 feet. A 100 m wave has 328 feet between crests, Figure 2.

Electromagnetic radiation, besides having a length λ, also has a frequency ν, the Greek letter nu. Frequency is a measure of how fast the wave travels per second or 1/sec. If you count the number of crests that pass your point of observation

in 1 second, you have measured the wave's frequency. For instance if you count 457 crests in one second, then $\nu = 457/\text{sec}$. This is also known as 457 Hz where Hz stands for Hertz and is another name for per second or $1/\text{sec}$.

Figure 2 – Frequency and Wavelength⁵



In Figure 1, high-energy gamma rays have a very high frequency in the range of 10^{21} Hz (1 with 21 zeroes before the decimal point) with a short wavelength $\lambda = 2.998 \times 10^{-12} \text{ cm} \approx 3 \text{ pcm}$ (see Eqn (1.2) below) . For the case of low energy (medium wave, MW) radio waves, ν is in the range of 10^6 Hz. For even lower energy, consider the $\nu = 60$ cycle (60 Hz) current that comes from the wall sockets in your home with a wavelength of about 5,000 km. Audio frequencies range from about $10^{4.6}$ Hz to less than 1 Hz, although frequencies below about 20 Hz are felt, not heard.

In Figure 2, if the time scale ticks each represent 1 sec, then the dashed-red curve has a frequency of 2 in 6 seconds, 0.333 sec^{-1} . The solid blue curve has a higher frequency of 8 in 6 seconds, 1.33 sec^{-1} .

Relationship of energy to wavelength

It is crucial to our argument to establish the relationship between energy and wavelength. If an electromagnetic wave is going to break a chemical bond, thus leading to possible cancer growth, then its energy must exceed that of a chemical bond in a DNA or other cellular molecule. The relationship between energy E and frequency ν is:

$$E = h\nu \quad (1.1)$$

Frequency has the units of s^{-1} or 1/sec or Hz. In Equation 1.1 h is the Planck constant, a fundamental parameter, whose value is 6.62×10^{-27} erg sec. The erg⁶ is a unit of energy. The relation between wavelength λ and frequency ν is

$$\lambda = c / \nu \quad (1.2)$$

where $c = 2.998 \times 10^{10}$ cm sec^{-1} is the velocity of light, (29,980,245,800 cm per second), another fundamental physical constant. Combining Equations 1.1 and 1.2 gives

$$E = hc / \lambda \quad (1.3)$$

as the energy in ergs of a given wavelength measured in centimeters (cm). Energy is proportional to the reciprocal of wavelength. As energy goes up, the wavelength goes down and vice-versa.

Above, electromagnetic radiation was described as a wave moving through space. An equivalent description is to describe electromagnetic radiation as packets of quanta also known as photons. These photons have a frequency ν and deliver energy in discrete packets, much like a bullet, with their individual energies given by Eqn. (1.1). It is important to note that a chemical bond will not be broken unless the delivered energy of the photon exceeds the bond energy between two atoms in the (DNA) molecule. The effect is not cumulative: three photons each having half the bond energy will not break a bond. The intensity of radiation does not make it a cancer agent, but its energy (frequency) does.

An erg is a very small amount of energy: (It has been suggested that 1 erg is approximately the amount of energy required for a mosquito to take off, see Note iv) one erg equals 2.3889×10^{-8} calories (one calorie is the energy required to raise the temperature of 1 gm of water - about 1/5 teaspoon - 1 centigrade degree). It is convenient in what follows to express energies in kilocalories (kcal) rather than ergs. For a point of reference, a *nutritional* Calorie is equal to 1,000 calories.

What is the strength of a chemical bond?

Carbon-carbon bond energies average 80.5 kcal/mole⁷. The mole refers to an Avogadro's Number of molecules in a gram molecular weight (mole) of a substance, for example 58.45 g of table salt⁸. The number of molecules is 6.0238×10^{23} , a very large number. Rather than referring energies to individual molecules, we will use the per mole designation. Otherwise, the numbers become too small to comprehend easily. For this reason, we will continue to express energy as kcal/mole.

The important parameter for cancer initiation is that the energy is above 70.5 kcal/mole. Because the average carbon-carbon bond energy is 80.5 kcal/mole, an additional 10 kcal/mole allowance is subtracted as a conservative safety factor. Damage to DNA and other molecules may occur only at energies greater than about 70.5 kcal/mole. This is consistent with the known fact that 400 nm UV-A radiation at 71.4 kcal/mole can cause skin cancer. See Table 2.

Water, fat, and sugars in the food absorb energy through a process called dielectric heating. Many molecules such as water are electric dipoles. A water molecule has a partial positive charge at one end and a partial negative charge at the other because of the spatial arrangement of the oxygen and two hydrogen atoms. In the presence of an EM (electromagnetic) field, such molecules rotate or wiggle as they try to align themselves with the rapidly alternating electric field of the microwaves. This rapid motion absorbs energy from the EM field and appears as heat.

Microwave ovens cook food because their energy is tuned to 2.46 GHz, the Goldilocks' frequency needed to cause dipoles in water molecules to absorb energy efficiently. This rotational energy is given up as heat. As a result, the food cooks without breaking any chemical bonds as long as water is present. As the last of the water disappears through vaporization, the EM field energy continues to be absorbed by other dipoles until the heat being generated catastrophically destroys (burns) the food.

A microwave oven is dangerous to tissue (living or otherwise) not because it disrupts the chemical bonds in DNA but because, through dielectric heating it boils the water away, cooking and finally charring the tissue because of the energy absorption by dipoles in the fats, sugars, and other substances.

Cell Phones

Cell phones operate with wavelengths in the region of 100 cm (1 m) corresponding to an energy of $2.86\text{E-}05$ kcal/mole. This is $8.05\text{E+}01/2.56\text{E-}05 \approx 2,820,000$ times less energy than required to break chemical bonds. For this reason, it is highly unlikely that Cell Phone use will cause cancer by damaging cellular components such as DNA

Summary

Table 1 shown that the energies of the cell-phone photons ($2.86\text{E-}05$ kcal/mole) are far less than the 80.5 kcal/mole required to break Carbon-Carbon bonds. In fact, cell phone radiation has 2.81 million times less ($80.5/2.86\text{E-}05$) energy than that required for breaking chemical bonds. Cell phone radiation will not initiate cancer through breaking of chemical bonds.

Using the same reasoning, radiation associated with microwave ovens or Wi-Fi systems do not have enough energy by a factor of roughly 300,000 to initiate cancer growth consistent with the generally accepted mechanism (Appendix E).

Web References

Many studies have been conducted to find out if there is a relation between cell phone usage and brain cancer. These may be found at various sites:

http://en.wikipedia.org/wiki/Mobile_phone_radiation_and_health (site last visited 6/7/2016)

<http://www.cancer.gov/cancertopics/factsheet/Risk/cellphones> (site last visited 6/7/2016)

http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf (site last visited 6/7/2016)

<http://pressroom.cancer.org/index.php?s=43&item=312> (site last visited 6/7/2016)

<http://www.niehs.nih.gov/health/topics/agents/cellphones/index.cfm> (site last visited 6/7/2016)

[http://www.fda.gov/Radiation-](http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/default.htm)

[EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/default.htm](http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/default.htm)

(site last visited 6/7/2016)

http://www.cdc.gov/nceh/radiation/cell_phones_FAQ.html (site last visited 6/7/2016)

The last five of these URL's are from Lee Koo¹⁰.

As with any publication, one must carefully look at how the raw data is interpreted. Because the raw data is both voluminous and virtually unobtainable to the public, we must trust the authors to present fairly their arguments. A typical phrase (besides an admonition¹¹ that “more studies are needed”) in many of the sites above and to links contained therein is:

Results to date have been inconclusive. While some experimental data have suggested a possible link between exposure and tumor formation in animals exposed under certain specific conditions, the results have not been independently replicated.

In none of the papers reviewed by this author was a positive link found between brain cancer and cell phone usage. This result is not unexpected in view of the physics explained above.

However, it is always possible to find web sites promoting the contrary view that cell phones do cause cancer. The one cited here is an example. The scientific background you have learned in this paper will make you skeptical about the views and presentation: http://www.lef.org/magazine/mag2007/aug2007_report_cellphone_radiation_01.htm. (site last visited 6/7/2016)

Recent Publications

A

An important research paper has recently appeared in *Cancer Epidemiology*, June 2016, **42**, pp 199-205. Pay attention to the fourth item under Highlights. This study includes the years 1982 through 2013 with mobile phone use beginning in 1987.

“Has the incidence of brain cancer risen in Australia since the introduction of mobile phones 29 years ago?” Simon Chapman, Lamiae Azizi, Qingwei Luo, Freddy Sitas

DOI: <http://dx.doi.org/10.1016/j.canep.2016.04.010> (site last visited 6/4/2016)

[http://www.cancerepidemiology.net/article/S1877-7821\(16\)30050-9/abstract](http://www.cancerepidemiology.net/article/S1877-7821(16)30050-9/abstract) (site last visited 6/4/2016)

The Highlights and Abstract from this paper are:

Highlights

- Mobile phone use in Australia began in 1987. Use is now over 90%.
- Brain cancer incidence between 1982 and 2013 has not increased in any age group except those aged 70–84; in the latter group, the increase began in 1982, before mobile phones were introduced.
- We hypothesize the increases in incidence of brain cancer in the oldest age group are due to improved diagnostic detection.
- We found no increase in brain cancer incidence compatible with the steep increase in mobile phone use.

Abstract

Background

Mobile phone use in Australia has increased rapidly since its introduction in 1987 with whole population usage being 94% by 2014. We explored the popularly hypothesised association between brain cancer incidence and mobile phone use.

Study methods

Using national cancer registration data, we examined age and gender specific incidence rates of 19,858 male and 14,222 females diagnosed with brain cancer in Australia between 1982 and 2012, and mobile phone usage data from 1987 to 2012. We modelled expected age specific rates (20–39, 40–59, 60–69, 70–84 years), based on published reports of relative risks (RR) of 1.5 in ever-users of mobile phones, and RR of 2.5 in a proportion of ‘heavy users’ (19% of all users), assuming a 10-year lag period between use and incidence.

Summary answers

Age adjusted brain cancer incidence rates (20–84 years, per 100,000) have risen slightly in males ($p < 0.05$) but were stable over 30 years in females ($p > 0.05$) and are higher in males 8.7 (CI = 8.1–9.3) than in females, 5.8 (CI = 5.3–6.3). Assuming a causal RR of 1.5 and 10-year lag period, the expected incidence rate in males in 2012 would be 11.7 (11–12.4) and in females 7.7 (CI = 7.2–8.3), both $p < 0.01$; **1434 cases observed in 2012, vs. 1867 expected** (emphasis mine). Significant increases in brain cancer incidence were observed (in keeping with modelled rates) only in those aged ≥ 70 years (both sexes), but the increase in incidence in this age group began from 1982, before the introduction of mobile phones. Modelled expected incidence rates were higher in all age groups in comparison to what was observed (emphasis mine). Assuming a causal RR of 2.5 among ‘heavy users’ gave 2038 expected cases in all age groups.

Limitations

This is an ecological trends analysis, with no data on individual mobile phone use and outcome.

What this study adds

The observed stability of brain cancer incidence in Australia between 1982 and 2012 in all age groups except in those over 70 years compared to increasing modelled expected estimates, suggests that the observed increases in brain cancer incidence in the older age group are unlikely to be related to mobile phone use. Rather, we hypothesize that the observed increases in brain cancer incidence in Australia are related to the advent of improved diagnostic procedures when computed tomography and related imaging technologies were introduced in the early 1980s.

B

A draft report was released 5-19-2016 by the National Toxicology Program as a ‘not peer-reviewed’ preprint <http://biorxiv.org/content/biorxiv/early/2016/05/26/055699.full.pdf> (site last visited 6/7/2016)

“Report of Partial Findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats (Whole Body Exposures)”

Unfortunately, this study did not answer the basic question about cell phone use and cancer in humans. However, it did unleash a media barrage of news articles of questionable value.

Appendix A (Mayo Clinic)

(From: <http://www.mayoclinic.org/diseases-conditions/cancer/basics/causes/con-20032378> (site last visited 6/7/2016))

Causes

Cancer is caused by changes (mutations) to the DNA within cells. The DNA inside a cell contains a set of instructions telling the cell how to grow and divide. Errors in the instructions may allow a cell to become cancerous.

What do gene mutations do?

A gene mutation can instruct a healthy cell to:

- **Allow rapid growth.** A gene mutation can tell a cell to grow and divide more rapidly. This creates many new cells that all have that same mutation.
- **Fail to stop uncontrolled cell growth.** Normal cells contain genes called tumor suppressor genes that recognize out-of-control growth and act to stop it. However, if a mutation occurs in a tumor suppressor gene, that gene may become less effective or may be turned off completely. This allows a mutated cell to continue growing and dividing.
- **Make mistakes when repairing DNA errors.** DNA repair genes identify and correct DNA mutations. A mutation in a DNA repair gene means that the gene may miss some DNA errors. This allows more DNA mutations to occur and may lead to cancer.

These mutations are the most common ones found in cancer. However, many other gene mutations can contribute to causing cancer.

What causes gene mutations?

Sometimes you are born with a genetic mutation. Alternatively, a genetic mutation can be caused by forces within your body, such as hormones, viruses, and chronic inflammation. Genetic mutations can also be caused by forces outside of your body, such as ultraviolet (UV) light from the sun, cancer-causing chemicals (carcinogens) or radiation.

How do gene mutations interact with each other?

Researchers believe that more than one gene mutation is necessary to cause most cancers. Some blood cancers may require just one gene mutation to drive their growth. Most cancers that form in the body's major organs, such as the lungs and the colon, have many gene mutations. It is not clear just how many mutations must accumulate for cancer to form. It is likely that this varies among cancer types.

The gene mutations you are born with and those that you acquire throughout your life work together to cause cancer. For instance, if you have inherited a genetic mutation that predisposes you to cancer, that does not mean you are certain to get cancer. Instead, you may need one or more other gene mutations to cause cancer. Your inherited gene mutation could make you more likely than other people to develop cancer when exposed to a certain cancer-causing substance. The genetic mutation begins the cancer process, and the cancer-causing substance could play a role in further cancer development.

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End Notes

¹ [CBS: Woman Says Her Wi-Fi Connection Is Making Her Sick](http://www.rushlimbaugh.com/daily/2015/05/21/wi-fi_sickness_sweeps_the_nation) through http://www.rushlimbaugh.com/daily/2015/05/21/wi-fi_sickness_sweeps_the_nation

² <http://en.wikipedia.org/wiki/Mutation>

³ http://www.vias.org/feee/frequency_band_survey.html (site last visited 6/7/2016)

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⁴ https://en.wikipedia.org/wiki/Cellular_frequencies

⁵ <http://www.cdc.gov/niosh/mining/topics/electrical/commtrackingtutorial/commtrackingtutorial.htm> (not available 6/7/2016)

⁶ An erg is a very small amount of energy. It has been suggested that 1 erg is approximately the amount of energy required for a mosquito to take off: <http://whatis.techtarget.com/definition/erg> (site last visited 6/7/2016)

⁷ Kenneth S. Pitzer, *Quantum Chemistry*, New York: Prentice Hall (1953), p. 170, LCCC 53-7717

⁸ Table salt is sodium chloride, NaCl. The sum of the atomic weights: $22.997 + 35.457 = 58.454$, the gram molecular weight of sodium chloride

⁹ http://en.wikipedia.org/wiki/Microwave_oven (site last visited 6/7/2016)

¹⁰ Lee Koo (ADMIN) at <http://forums.cnet.com> (site last visited 6/7/2016)

¹¹ From a personal point of view, I find that such a comment is somewhat self-serving in that it suggests the need for (massive?) additional funding when such is not warranted based on the (quite considerable) available evidence that cancer is not causally linked to cell phone use. (E. L. Lippert).

Supplemental information added 05 Feb 2018.

Submit your written comments to [REDACTED] by email sent to [REDACTED] to the National Toxicology Program (NTP)

https://www.nytimes.com/2018/02/02/health/cell-phones-cancer.html?WT.mc_id=SmartBriefs-Newsletter&WT.mc_ev=click&ad-keywords=smartbriefs

<https://ntp.niehs.nih.gov/about/org/sep/trpanel/meetings/docs/2018/march/index.html>

Draft Reports, Public Comments, and Related Information: TR Peer Review Panel

Draft Technical Reports

- [TR-595: NTP Studies of Cell Phone Radiofrequency Radiation \(Rats\)](#)
- [TR-596: NTP Studies of Cell Phone Radiofrequency Radiation \(Mice\)](#)

Supplemental Materials

- Capstick et al. A radio frequency radiation exposure system for rodents based on reverberation chambers. IEEE Trans Electromagn Compat. 2017; 59(4):1041-1052 <https://doi.org/10.1109/TEMC.2017.2649885>
- Gong et al. Life-time dosimetric assessment for mice and rats exposed in reverberation chambers for the two-year NTP cancer bioassay study on cell phone radiation. IEEE Trans Electromagn Compat. 2017; 59(6):1798-1808 <https://doi.org/10.1109/TEMC.2017.2665039>
- [Wyde et al. Effect of cell phone radiofrequency radiation on body temperature in rodents: Pilot studies of the National Toxicology Program's reverberation chamber exposure system. Accepted for publication by Bioelectromagnetics \(January 30, 2018\)](#)

Data Tables for Peer Review

- [TR-595: Data for NTP Studies of Cell Phone Radiofrequency Radiation \(Rats\)](#)
- [TR-596: Data for NTP Studies of Cell Phone Radiofrequency Radiation \(Mice\)](#)

Submission guidelines for written comments:

<https://ntp.niehs.nih.gov/about/org/sep/trpanel/meetings/index.html#20180328>

Cell Phones, Microwave Ovens, and Wi-Fi – Can They Cause Cancer?, Ernest L. Lippert, 05 February 2018 (r06), , including this page, was submitted as a public comment to the National Toxicology Panel (NTP) on 16 Feb 2018.